

FACIAL EXPRESSION OF POSITIVE EMOTIONS IN INDIVIDUALS WITH
EATING DISORDERS

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*Highlights

- We explored Duchenne smiles in women with anorexia (AN), bulimia (BN), and controls (HC).
- AN showed Duchenne smiles for shorter durations than BN and HC participants.
- AN participants' Duchenne smiles were less intense than those of BN and HC.
- Reduced Duchenne smile was related to low BMI, and use of medication.
- Results provide further evidence of difficulties in emotion processing in AN.

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Abstract

A large body of research has associated Eating Disorders with difficulties in socio-emotional functioning and it has been argued that they may serve to maintain the illness. This study aimed to explore facial expressions of positive emotions in individuals with Anorexia Nervosa (AN) and Bulimia Nervosa (BN) compared to healthy controls (HC), through an examination of the Duchenne smile (DS), which has been associated with feelings of enjoyment, amusement and happiness (Ekman et al., 1990). Sixty participants (AN=20; BN=20; HC=20) were videotaped while watching a humorous film clip. The duration and intensity of DS were subsequently analysed using the Facial Action Coding System (FACS) (Ekman and Friesen, 2003). Participants with AN displayed DS for shorter durations than BN and HC participants, and their DS had lower intensity. In the clinical groups, lower duration and intensity of DS were associated with lower BMI, and use of psychotropic medication. The study is the first to explore DS in people with eating disorders, providing further evidence of difficulties in the socio-emotional domain in people with AN.

Keywords: Anorexia Nervosa, Bulimia Nervosa, Duchenne smile, Facial Expression, Emotion

1. Introduction

Facial expressions play a key role in human social interaction. They convey people's emotional experience (Ekman, 1992) and are used as social signals that communicate information to others (Fridlund, 1994). They are also essential for establishing rapport (Tickle-Degnen, 2006), deepening people's sense of connection and alliance during social interaction (Schmidt and Cohen, 2001). In contrast, lack of facial expression can be interpreted as an attempt to avoid attention in social settings, becoming undetected (Fridlund, 1994). Studies on individuals with limited facial expression indicate that people perceive them as reserved and unhappy (Tickle-Degnen and Doyle Lyons, 2004; Bogart et al., 2014) and report being less interested in establishing friendship ties with them (Hemmesch et al., 2009).

Facial expressions of positive emotions, such as smiling, have been related to cooperative intentions (Schmidt and Cohen, 2001), readiness to play or connect (Fridlund, 1994), and social rewards (Shore and Heerey, 2011). People associate smiling with happiness, positive intentions (Floyd and Burgoon, 1990), and increased sociability (Matsumoto and Kudoh, 1993).

Early on, Charles Darwin noted that spontaneous smiles were characterized by the activation of the muscle that contracts the outer corner of the eyebrows (i.e., orbicularis oculi) producing wrinkles in the corner of the eyes, in addition to the zygomaticus major, which moves the corner of the lips upwards towards the cheekbones (Darwin, 1872). This is known as the Duchenne smile (DS) (Duchenne, 1990; Ekman et al., 1990). DS have been associated with reports of enjoyment, amusement and happiness (Ekman et al., 1990; Ruch, 1995), as well as specific patterns of brain activity (Ekman, 1990, Davidson et al., 1990). In contrast, Non-Duchenne smiles (NDS) do not involve the action of the orbicularis oculi, and are not

associated with the experience of positive affect. Whereas DS have shown to evoke positive emotions in others, promoting positive social interactions and well being, NDS do not (Keltner and Bonanno, 1997; Harker and Keltner, 2001). Instead, NDS may be displayed in a deliberate attempt to convince others that a positive emotion is being felt when it is not (Ekman and Friesen, 1982), or as a way of signalling anticipation of the possibility of experiencing enjoyment (Ekman et al., 1990), and is often produced in response to social demands (Hess and Bourgeois, 2010).

Facial expression is part of a coordinated system of emotional responses (Levenson, 1994). It has been argued that in people who experience psychological difficulties, elements of this system may lack coordination, thus becoming dysfunctional (Rosenberg and Ekman, 1994). Studies in clinical populations have shown differences in the expression of DS in response to positive stimuli, compared to healthy controls (HC). For example, individuals suffering from depression have been found to produce fewer DS when exposed to positive stimuli (Ekman et al., 2005) and to show smiles that were followed by negative affect-related expressions in response to amusing film clips (Reed et al., 2007). Participants with schizophrenia display fewer DS when induced to feel positive emotions through remembering biographic emotional situations (Kohler et al., 2008). Similar results have been found for participants with post-traumatic stress disorder during a psychodynamic interview (Kirsch and Brunnhuber, 2007).

Eating disorders are characterized by disturbances in patients' eating patterns, body image or body weight, which may lead to physical, cognitive or social difficulties (Fairburn and Harrison, 2003; Tchanturia et al., 2013). People with eating disorders exhibit high levels of comorbidity with disorders that have shown to be related to reduced facial expression, such as anxiety and depression (Herzog et al., 2000). In addition, socio-emotional difficulties

found in eating disorders include high levels of alexithymia (Nowakowski, et al., 2013), social anhedonia (Tchanturia et al., 2012), self-silencing (i.e., the tendency to avoid expressing negative emotions) (Hambrook et al., 2011), and fear of the social consequences of expressing emotions (Ioannou and Fox, 2009; Hambrook et al., 2011). It has been proposed that socio-emotional difficulties may contribute to the maintenance of the eating disorder psychopathology (Treasure et al., 2012; Schmidt and Treasure, 2006; Speranza et al., 2007) and in the case of AN, that eating disorder symptoms function, in part, to help the individual cope with aversive emotional states (Wildes et al., 2010).

A few studies have investigated facial expressions in people with eating disorders (Davies et al., 2011; Davies et al., 2013; Rhind et al., 2014). Davies and colleagues (2011) found that adult AN patients showed fewer facial expressions when watching negative and positive films, and reported feeling less positive emotions and similar levels of negative emotions, compared to HC. Similar results were described in young people with AN (Rhind et al., 2014). Claes and colleagues (2012) used a different experimental procedure to monitor facial expression of anger and joy in AN and BN participants when playing a therapeutic video game and reported that AN patients exhibited less anger through their facial expressions compared to HC. In BN participants, facial expression of anger was not significantly reduced compared to HC. The study found no differences among the groups in their facial expressions of joy. In a second study using the same paradigm, patients with BN showed higher levels of joyous facial expressions, and reduced facial expression of anger compared to HC (Tarrega et al., 2014). Reduced expression of emotions may contribute to the difficulties in the socio emotional area, worsening the impact of the eating disorder in patients' social functioning (Tchanturia et al., 2013).

The studies described above provide preliminary evidence suggesting that patients with AN and BN show reduced negative facial emotional expression (sadness and anger) compared to HC. However, results for facial expressions of positive emotions are more equivocal: AN showed fewer positive facial expressions compared to HC when using film clips as mood elicitors, but not when using a video game. Furthermore, BN participants seem to display as many positive facial expressions as HC. Studies on positive emotions are scarce in the eating disorders field, and there is a need for further investigation in the area (Tchanturia, 2015). Therefore, this study aimed to build upon previous findings, by further investigating positive facial expression of emotions in AN and BN. Specifically, examining the expression of DS as an expression of genuine positive affect and potential benefits for well being, in comparison to NDS.

Based on previous findings, it was hypothesized that participants with AN will show fewer DS and NDS, compared to HC. Even though the literature on BN is more limited, it was hypothesized that this group will produce similar levels of DS and NDS to HC. To our knowledge, this is the first study to investigate DS in people with eating disorders.

2. Method

2.1. Participants

Sixty adult women, grouped into 20 AN (9 restricting type, and 11 binge-eating/purging type), 20 BN and 20 HC, were included in the study. Given that studies using FACS were not available in the eating disorders literature, studies carried out on other psychiatric populations (mainly schizophrenia and mood disorders) were used to estimate the sample size. It was estimated that a sample size of 20 participants per group would allow detecting medium to large effect sizes with 80% of power, setting $\alpha < 0.01$. Participants with

eating disorders were recruited from specialist eating disorders services, and through advertisement on the Beat website (<http://www.b-eat.co.uk/>). The HC group was recruited from the local community. Eating disorder diagnosis was assessed using the Eating Disorders module of the Structured Clinical Interview for DSM-IV-TR Axis I Disorders (SCID-I) (First et al., 2002). The inclusion criterion for the clinical groups was a diagnosis of AN or BN, according to DSM-5 (APA, 2013). A body mass index less than 18.5 was used as a threshold for AN diagnosis. Participants were excluded from the study if they have had a head injury, autism spectrum disorders, and psychosis, were not fluent in English, or were unable to provide informed consent. The same exclusion criteria as well as the absence of current or past eating disorder were applied for the HC group. Participants were compensated for their time with £10.

2.2. Measures

2.2.1. Body mass index (BMI in kg/m²): This was calculated from measures of height and weight obtained on the day of the assessments.

2.2.2. Structured Clinical Interview for DSM disorders (SCID-I) (First et al., 2002): The eating disorders module of the SCID-I was used to assess current or past diagnosis in all participants. In order to adjust the interview to DSM-5 criteria, amenorrhea was not required for AN diagnosis, and the frequency of binge eating and purging behaviour was reduced to once a week for the diagnosis of BN.

2.2.3. Eating Disorder Examination Questionnaire (EDE-Q) (Fairburn and Beglin, 1994): This 36 item self-report questionnaire is designed to assess eating disorders symptomatology. It has four subscales (i.e., dietary restraint, eating concern, weight concern, and shape concern) and a global score that ranges from 0 to 6.

2.2.4. Hospital Anxiety and Depression Scale (HADS) (Zigmond and Snaith, 1983): The HADS is a 14-item self-report questionnaire with two subscales assessing anxiety and depression levels. Each subscale ranges from 0 to 21. The questionnaire has shown to have good validity and reliability (Bjelland et al., 2002).

2.2.5. Toronto Alexithymia Scale (TAS-20) (Bagby et al., 1994): A 20 item questionnaire widely used to assess alexithymia, which is defined as difficulty in identifying and describing emotions. This questionnaire has good psychometric properties (Parker et al., 2003). The questionnaire consists of three subscales (i.e., difficulty identifying feelings, difficulty describing emotions, and externally oriented thinking) and a total score that ranges from 20 to 100.

2.2.6. Positive and Negative Affect Scale (PANAS) (Watson et al., 1988): The PANAS is a 20 items two-factors self-report scale developed to assess positive and negative affect. In the current study, the positive affect scale was used to assess the extent to which the film clip was able to induce positive affect in the participants. The positive affect PANAS scale has 10 descriptors (i.e., attentive, interested, alert, excited, enthusiastic, inspired, proud, determined, strong, and active) and its score ranges from 10 to 50.

Internal consistencies (α) for the measures in the current sample were: EDE-Q: 0.98; HADS Anxiety: 0.72; HADS Depression: 0.69; TAS-20: 0.92; and PANAS positive: 0.89.

2.3. Experimental Task

First, a neutral film depicting waves was presented for 30 seconds. Next, participants completed the positive PANAS questions (pre-film), in order to establish a baseline measure of positive affect before the emotion elicitation. Following this, a 2 minutes clip showing a

humorous wedding ceremony was shown. This clip was taken from the film “Four Weddings and a Funeral” and it was chosen because it has shown in previous studies to elicit positive emotions in people with AN and HC (e.g. Davies et al., 2011). Finally, the positive PANAS questions were repeated (post-film). Participants were alone during the task and were aware that they were being recorded. Videos and instructions were shown on a 13-inches laptop computer screen with a built-in camera that recorded the participant’s facial expressions during the task.

2.4. Procedure

Participants attended one session during which all procedures were carried out. As part of the informed consent participants were informed that the purposed of the study was “to explore the way people with and without eating disorders deal with emotions”, and were asked for their permission to be videotaped during the experimental procedures. After they gave their informed consent, the SCID was conducted, and weight and height were measured. Then, participants completed the experimental task and questionnaires. The videos showing participants' facial expressions while watching the humorous film were then coded using the Facial Action Coding System (FACS). The study was approved by the National Health Research Ethics Services Committee (13/LO/0201).

2.5. Coding of Facial Expression

The Facial Action Coding System (FACS) was developed by Ekman and Friesen for measuring observable facial expressions (Ekman and Friesen, 2003). It provides a method to objectively code any anatomically possible action produced in the face using 44 action units

(AUs), in which each AU describes the movement of specific muscles in the face. The coding system can be used to identify action units (AUs), their intensity, as well as combinations of AUs. In FACS, the DS is identified as a combination of AU12 (lip corners pulling, by the action of the zygomaticus major) and AU6 (cheek raising, by the action of the orbicularis oculi), and differentiated from NDS, which does not involve AU6. For a detailed description of FACS, see Ekman and Rosenberg (2005).

Videos were coded by two coders (SH; CH), who were blind to the participants' clinical status (AN, BN, or HC) and to the study hypotheses, under the supervision of MMD. All coders were certified in FACS. All 44 AUs were coded, and then AU6 and AU12 were selected for analysis. Duration and intensity were used as outcome measures. A measure of proportional viewing duration was calculated by dividing the time (in seconds) a participant had spent displaying the AU combination by the task duration in minutes. For example, if a participant displayed an AU combination for a total of 4 seconds during the 2-minute film clip then the measure would be 4 seconds divided by 2 minutes. The intensity of the AU combination was coded on a 5-point ordinal scale, from trace to maximum intensity.

The AU combinations for DS and NDS were coded exclusively, and did not overlap. In order to assess inter-coder reliability for AU6 and AU12, seven videos (12%) were coded by both coders (SH; CH). The overall agreement percentage was 92%. Mean Cohen's Kappa was 0.80, which indicates excellent agreement (Sayette et al., 2001).

2.6. Data Analysis

SPSS version 22 was used to analyse the data. Prior to conducting all analyses, distributions were examined to evaluate normality. Non-parametric analyses of variance were

conducted for data that was not normally distributed (Kruskal-Wallis and Mann–Whitney U post-hoc tests). Effect sizes were calculated by using Cohen’s *d* (Cohen, 2013) for parametric tests, and Rosenthal’s *r* (Rosenthal and Rubin, 2003) for non-parametric tests. In order to test the mood induction, repeated measures ANOVA was used comparing pre-film and post-film PANAS (within-group) among the three groups (AN, BN, or HC; between-subject factor). ANOVA and post-hoc t-tests were performed to compare the three groups on smile duration and intensity, when data was normally distributed. In order to explore associations of DS and NDS in the clinical group, AN and BN participants were grouped together (n=40) and Spearman correlations were calculated between the smiles and BMI, length of illness, EDE-Q, HADS-A, HADS-D, and TAS-20 measures. To explore the effect of medications in DS and NDS the clinical group was split into clinical participants who were taking medications (n=17) and those who were not (n=23). Mann Whitney U test and Rosenthal’s *r* effect size were calculated to compare the duration and intensity of DS and NDS in both groups. Bonferonni correction for multiple testing was applied.

3. Results

Participant’s demographic and clinical characteristics are described in Table 1. As expected, clinical participants differed from HC on measures of eating disorders, anxiety, depression, and alexithymia. In addition, AN participants had lower BMI than BN and HC groups. Eating disorder participants did not differ on EDE-Q subscales, although there was a trend towards significant difference in dietary restraint (EDE-Q diet. rest.: $M_{AN}= 4.29$, $M_{BN}=3.31$, $t(38)= 1.98$, $p=0.06$). There was no difference in the length of illness of AN and BN participants.

----- INSERT TABLE 1----

Sixty percent of the participants with AN were taking psychotropic medication at the time of the study (n=12). The majority was using a combination of selective serotonin reuptake inhibitors (SSRI) and Olanzapine (n=4), or SSRI exclusively (n=3); other AN participants were taking benzodiazepines (n=2) or other psychotropic medication (n=3). On the other hand, 25% of the participants with BN were using psychotropic medication (n=5), all taking SSRI. None of the HC participants was taking psychotropic medications.

3.1. Mood induction

Pre-film and post-film PANAS were compared to test the extent to which the film had been able to produce a change in participants' affect. Results indicated that there was a significant effect of film, with a significant increase in positive affect after viewing the film ($F(1,57)= 18.7, p < 0.01$). There was no significant effect of group ($F(2,57)=0.8, p=0.44$) and the group X film interaction was not significant ($F(2,57)= 0.5, p= 0.62$), suggesting similar increase in positive affect in all groups after viewing the film clip (Figure 1).

----- INSERT FIGURE 1-----

3.2. Duchenne smiles (DS)

Analyses of variance revealed that the groups differed significantly in duration and intensity of DS (Table 2). Post-hoc tests indicated that the AN group had significantly less DS duration and intensity compared to the BN group and to the HC group. BN participants did not differ from HC on intensity and duration. Effect sizes were between medium and large.

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3.3. Non-Duchenne smiles (NDS)

The analyses of variance indicated that the groups differed in duration and intensity of NDS. Post-hoc analyses showed less duration of NDS for both eating disorder groups compared to HC. AN and BN groups were not found to significantly differ in their duration of NDS. AN participants were shown to have significantly less intense NDS compared to the BN and HC groups, but the BN group did not differ from the HC group on NDS intensity. Effect sizes were small to large.

3.4. Association with clinical characteristics within the clinical sample

In order to explore the association of DS and NDS with clinical characteristics, AN and BN participants were grouped together ($n=40$) and their association with BMI, length of illness, eating disorder symptoms, anxiety, depression, and alexithymia was investigated. It was decided to investigate the clinical group as a whole because of the evidence of high diagnostic crossover between AN and BN (Eddy et al., 2008), and to ensure sufficient power for the analysis. Results indicated that in the clinical group, DS duration and intensity were significantly associated with BMI. None of the other clinical characteristics (length of illness, eating disorder symptoms, anxiety, depression, and alexithymia) were found to be significantly associated with DS. When exploring associations within the AN group ($n=20$), similar results were obtained with significant associations between DS intensity and BMI ($r_s=0.49$, $p=0.03$), and a trend towards significance in the case of DS duration and BMI ($r_s=0.44$, $p=0.05$).

In the eating disorders group, the duration of NDS was found to be negatively associated with TAS-20, and NDS intensity was significantly associated with BMI. NDS was not found to be associated with the other clinical measures (see Table 3). On the other hand, in the AN participants, NDS was associated with anxiety ($r_s=-0.50$, $p=0.02$).

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In regards to medication use, clinical participants who were taking psychotropic medications at the time of the study had less DS duration ($U(38)=117.00$; $p=0.03$; $r=-0.36$), and their DS were less intense ($U(38)=112.00$; $p=0.02$; $r=-0.39$). There were no differences on duration or intensity of NDS between medicated and non medicated clinical participants (duration: $U(38)=135.50$; $p=0.10$; intensity: $U(38)=163.00$; $p=0.39$).

4. Discussion

Smiles are potent social signals that are vital for human communication (La France, 2011), and thus their examination in people with eating disorders can offer significant insight into their socio-emotional functioning and contribute to treatment innovations. The present study aimed to investigate positive facial expression in people with eating disorders through an examination of Duchenne smile (DS) expressed in response to a positive, humorous film clip. It was hypothesised that participants with AN will exhibit reduced DS and NDS when compared to HC, and that BN participants will produce DS and NDS at similar levels to HC.

Results indicated that the film clip successfully increased positive emotions in all participants, but they differed in their facial expression. Specifically, participants with AN displayed DS for shorter durations than BN and HC participants, and their DS had lower intensity. These results extend previous findings of reduced positive facial expression in AN,

by obtaining similar results using a different, more detail-oriented facial expression coding system (Davies et al., 2011; Rhind et al., 2014).

Duchenne smiles (DS) express genuine or authentic enjoyment. Because emotion expression plays a central role in establishing relationships (Keltner and Kring, 1998), the reduced expression of DS in the AN group might reflect broad social-signalling difficulties. Indeed, inhibited emotional expression has been shown to make it more likely for others to perceive the inhibited person as untrustworthy or inauthentic (e.g., English and John, 2013) and to reduce social connectedness (e.g., Mauss et al., 2011). It has also been hypothesized that people who show reduced positive facial expression are trying to avoid people's attention (Fridlund, 1994). AN is a disorder highly comorbid with social phobia (Swinbourne et al., 2012) and there is evidence that people with AN maintain less eye contact than HC (Cipolli et al., 1989) and experience high levels of social anhedonia (Tchanturia et al., 2012; Harrison et al., 2014). In this context, it is likely that the reduced expression of positive affect would contribute to maintain this pattern of social avoidance in AN.

DS has also been associated with social reward (Shore and Heerey, 2011), therefore, the reduced expression of DS in the AN group may reflect diminished temperamental reward sensitivity that characterizes disorders of overcontrol such as AN, autism spectrum disorders, and obsessive compulsive personality disorder (Lynch et al., 2013; Lynch, in press). Heightened temperamental threat sensitivity and diminished reward sensitivity are hypothesized to bias a person to notice the potential for harm over the potential for reward when interacting with others or encountering ambiguous stimuli making it less likely for them to respond with genuine enjoyment or pleasure (Lynch et al., in press; Clark, 2005). Smiling faces have been shown to activate reward-anticipation areas in the brain (Aharon et

al., 2001) and AN has been shown to exhibit lower dopamine mediated anticipatory reward relative to BN (Kaye et al., 2013 for review).

Results of this study showed differences in the duration and intensity of DS between AN and BN participants, this may be explained at least in part, by the fact that BN is a disorder characterized by impulsivity (Harrison et al., 2010) while AN is characterized by overcontrol (Lynch et al., 2013). Our results are similar to findings from Claes and colleagues (2012) who did not find reduced facial expression of joy in BN participants.

Furthermore, participants within the clinical sample with lower BMI, were found to present DS at a lower duration and intensity, compared to those with higher BMI. Given that other eating disorder psychopathology measures, such as length of illness and EDE-Q, were not associated with DS, this finding suggests that starvation may explain, at least in part, the differences in the results found for people with AN and BN. Future studies including participants who are weight restored, but have AN related psychopathology may be able to enlighten the role of starvation in the expression of positive emotions in AN.

An alternative explanation for the differences between the clinical groups in the production of DS and NDS may relate to different levels of social anxiety in AN and BN. It is known that AN is highly comorbid with social phobia (Swinbourne et al., 2012), and there is preliminary evidence that shyness may influence social skills in AN (Wincoff et al., 2015). Since participants were aware they were being filmed during this study, those with AN may have experienced social anxiety and therefore may have been more cautious of their emotional expression. The negative associations between anxiety and both DS and NDS production may provide support for this explanation, even though they were not significant after correcting for multiple testing. Thus, the influence of social anxiety in positive emotion

expression when evaluated using videotaped tasks, such as the one used in the current study, may need further investigation.

In order to explore the effects of psychotropic medications in positive emotion expression (i.e. DS) the clinical group was split according to medication use. Participants taking medications (mostly on SSRI, either exclusively or in combination with olanzapine) showed significantly less DS duration and intensity. These findings may seem to contradict evidence of enhanced expression of positive emotions after SSRI treatment found in people with depression (Girard et al., 2014). However, it is worth noting that the majority of participants taking medications in this study were underweight (i.e. AN), and it is known that antidepressants are less effective in this population (Claudino, et al., 2009). One explanation for our findings may be that participants taking antidepressants were the ones with more severe depressive symptoms, and depression has been linked to reduced expression of positive affect (Ekman et al., 2005; Girard, 2014). However, in our study depressive symptoms did not correlate to duration or intensity of DS. Therefore, the relation between medication and expression of positive emotions remains unclear. To our knowledge, this is the first study to explore the effects of medication in emotion expression. The results highlight the need to further investigate the impact of psychotropic medication on emotion expression.

In contrast to the results for DS, differences between AN and BN participants on NDS were not statistically significant. Nevertheless, this result should be taken with caution, because the difference approached significance and the effect size was small, but not negligible. Thus, it is unclear whether the lack of difference between AN and BN participants reflects true similarities in NDS expression, or is a result of lack of power. Future studies

with a larger sample size might clarify the differences between AN and BN participants in NDS expression.

In this study, both AN and BN groups presented significantly less NDS duration than the HC group. NDS intensity was found to be significantly less for AN participants compared to BN and HC groups. NDS is usually shown in response to social demands (Hess and Bourgeois, 2010), and according to Papa and Bonanno (2008) NDS displayed in positive situations may be appropriate as a signal of social politeness, increasing social integration. Thus, results may indicate that people with eating disorders are less able to comply with social conventions related to the expression of positive emotions in positive contexts. Alternatively, people with eating disorders may be less expressive in general, for both emotional and non-emotional expressions.

In our study, clinical participants with higher levels of alexithymia showed lower NDS duration. Since NDS tend to be expressed as social conventions, rather than expressions of real enjoyment, this finding may suggest that in people with eating disorders, the difficulties identifying and verbalising internal emotional experiences relate to a lack of awareness of social conventions ruling the display of positive affect. It may be beneficial for future studies to explore this idea further.

The study findings have relevant clinical implications. People with AN have reported experiencing difficulties making friends before the eating disorder onset (Doris et al., 2014), and people with eating disorders report that their illness affects social relationships more than any other aspect of life (Tchanturia et al., 2013). Building new social relationships during recovery may be harder for individuals with eating disorders because people are less motivated in building friendships with individuals who do not express emotions (Hemmesch

et al., 2009). Moreover, reduced positive facial expression can have an impact on rapport (Tickle-Degnen, 2006), interfering with the therapeutic relationship during treatment.

This study provides further evidence for the need to include interventions aimed at improving socio-emotional processing of positive emotions in eating disorders treatment (Tchanturia et al., 2015), particularly in those with AN and using psychotropic medication. Research of this nature could inform already existing therapies addressing emotion functioning in eating disorders, such as Cognitive Remediation and Emotional Skills Training (CREST) (Tchanturia et al., 2014), Emotion Acceptance Behaviour Therapy (EABT) for Anorexia Nervosa (Wildes and Marcus, 2011), and Radically Open-Dialectical Behaviour Therapy (RO-DBT) (Lynch et al., in press).

There are limitations to the present study. For example, even though the researchers coding the videos were blind to the group allocation of the participants, some AN participants were visibly underweight and therefore their group allocation may have been revealed. In addition, all participants were female. Given the evidence that women tend to smile more than men (Hess and Bourgeois, 2010), it would be relevant to explore this area in men with eating disorders. Finally, the association analysis within the AN participants carried out in this study needs to be seen as exploratory, given the small sample size for the AN group. In future studies it would be desirable to include a higher number of participants to examine differences in AN and BN in facial expression of positive emotions.

Future research could replicate this study including a group of weight restored AN participants, to better understand the role of starvation in the results. In addition, studies should explore differences in the expression of negative emotions to better understand if the reduced expression exhibited by AN participants is specific to positive emotions, or

generalized to all emotions. Finally, future studies may aim to replicate these findings in social interaction paradigms.

To our knowledge, the study is the first to investigate DS as an expression of genuine positive affect in people with AN and BN. The findings provide empirical support of difficulties in facial expression of positive emotions in people with AN and underline the need to further explore the role of BMI and psychotropic medications in the expression of positive emotions in people with eating disorders.

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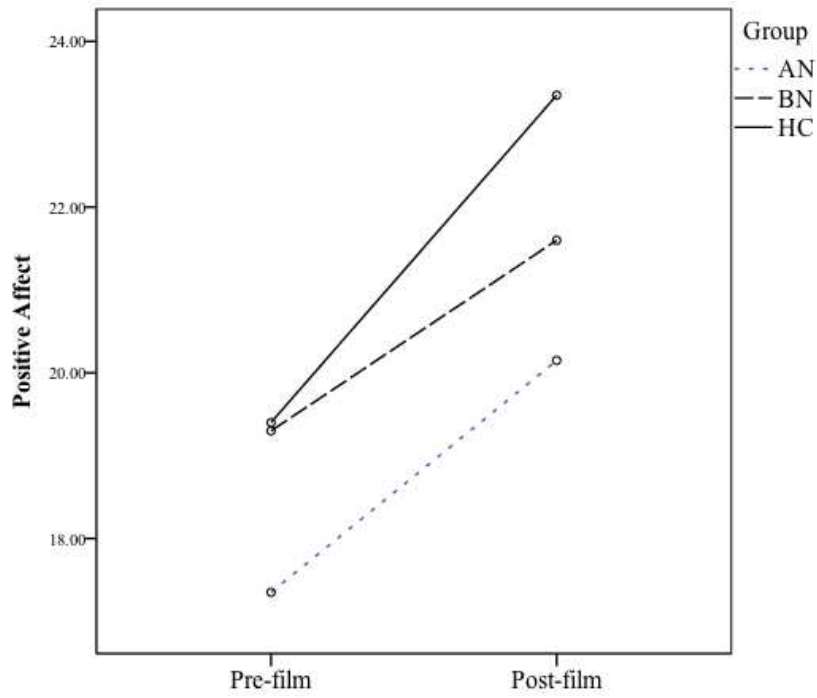
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Figure 1: Pre-film and post-film positive affect PANAS scores.



AN=Anorexia nervosa; BN= bulimia nervosa; HC= healthy controls.

Table 1. Demographic and clinical characteristics

	AN	BN	HC	Group	Post-hoc tests		
	(n=20)	(n=20)	(n=20)	Statistics	AN vs. BN	AN vs. HC	BN vs. HC
	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>				
Age	28.85 (9.75)	26.85 (6.75)	26.40 (7.60)	$F(2,57)=0.52$ $p=0.60$	N/A	N/A	N/A
BMI	15.59 (1.83)	22.15 (3.02)	22.47 (2.68)	$F(2,57)=45.97$ $p<0.01$	$t(38)=8.29$ $p<0.01$ $d=2.63$	$t(38)=9.49$ $p<0.01$ $d=3.00$	$t(38)=0.36$ $p=0.72$ $d=0.11$
Length of Illness	11.55 (11.26)	7.95 (6.46)	N/A	$t(38)=1.24$ $p=0.23$	N/A	N/A	N/A
EDE-Q	4.38 (1.04)	3.98 (1.37)	0.48 (0.42)	$F(2,57)=88.29$ $p<0.01$	$t(38)=1.02$ $p=0.31$ $d=0.32$	$t(25)=15.51$ $p<0.01$ $d=4.92$	$t(23)=10.97$ $p<0.01$ $d=2.82$
HADS-A	13.15 (3.60)	12.05 (2.82)	5.95 (1.85)	$F(2,57)=37.08$ $p<0.01$	$t(38)=1.08$ $p=0.29$ $d=0.34$	$t(28)=7.95$ $p<0.01$ $d=2.52$	$t(38)=8.09$ $p<0.01$ $d=2.56$
HADS-D	10.60 (3.15)	9.70 (3.39)	3.85 (1.60)	$F(2,57)=33.61$ $p<0.01$	$t(38)=0.87$ $p=0.39$ $d=0.28$	$t(28)=8.54$ $p<0.01$ $d=2.70$	$t(27)=6.98$ $p<0.01$ $d=2.21$
TAS-20	60.45 (4.79)	56.35 (14.25)	34.75 (2.52)	$F(2,57)=12.36$ $p<0.01$	$t(38)=0.95$ $p=0.35$ $d=0.39$	$t(26)=8.02$ $p<0.01$ $d=6.72$	$t(25)=6.27$ $p<0.01$ $d=2.11$

AN= anorexia nervosa; BN= bulimia nervosa; HC= healthy control; n= number of participants; *M*= mean; *SD*= standard deviation; *F*= Anova test; N/A= non applicable; BMI= body mass index; *t*= t-test; *d*= Cohen's *d* effect size test; EDE-Q= Eating disorders examination questionnaire; HADS-A= Hospital anxiety and depression scale, anxiety subscale; HADS-D= Hospital anxiety and depression scale, depression subscale; TAS-20 =

Toronto alexithymia scale.
Bonferonni correction applied, statistical significance at $p < 0.016$

Table 2: Duchenne and Non-Duchenne smiles in clinical and HC groups

	AN (n=20)	BN (n=20)	HC (n=20)	Group Statistics	Post-hoc tests		
	<i>Mdn (IQR)</i>	<i>Mdn (IQR)</i>	<i>Mdn (IQR)</i>		AN vs. BN	AN vs. HC	BN vs. HC
Duchenne smiles duration (sec/min)	0.00 (0.42)	0.83 (1.59)	2.08 (2.28)	$\chi^2(2)=15.86$ $p<0.01$	$U=114.00$ $p<0.01$ $r=0.39$	$U=71.50$ $p<0.01$ $r=0.57$	$U=115.00$ $p=0.02$ $r=0.37$
Duchenne smiles intensity	0.00 (1.75)	3.00 (2.50)	3.00 (1.50)	$\chi^2(2)=18.25$ $p<0.01$	$U=88.00$ $p<0.01$ $r=0.51$	$U=62.00$ $p<0.01$ $r=0.63$	$U=159.50$ $p=0.23$ $r=0.19$
Non Duchenne smiles duration (sec/min)	0.83 (1.66)	1.66 (2.50)	3.74 (2.49)	$\chi^2(2)=16.26$ $p<0.01$	$U=135.50$ $p=0.08$ $r=0.28$	$U=62.00$ $p<0.01$ $r=0.60$	$U=100.50$ $p<0.01$ $d=0.43$
Non Duchenne smiles intensity	2.00 (1.00)	3.00 (1.00)	3.00 (1.00)	$\chi^2(2)=20.26$ $p<0.01$	$U=107.50$ $p<0.01$ $r=0.41$	$U=49.00$ $p<0.01$ $r=0.67$	$U=115.50$ $p=0.02$ $r=0.34$

AN= anorexia nervosa; BN= bulimia nervosa; HC= healthy control; n= number of participants; *Mdn*= median; *IQR*= interquartile range; Sec/min= seconds per minute; *U*= Mann Whitney *U* test; χ^2 = Kruskal-Wallis test; *r*= Rosenthal's *r* effect size test; *t*= t-test; *d*= Cohen's *d* effect size test.

Bonferonni correction applied, statistical significance at **$p<0.016$**

Table 3: Correlations between DS, NDS and clinical characteristics within the clinical sample

	BMI	Length of Illness	EDE-Q	HADS-A	HADS-D	TAS-20
Duchenne smiles (duration)	$r_s=0.426$ $p=0.006$	$r_s=0.097$ $p=0.551$	$r_s=-0.053$ $p=0.746$	$r_s=-0.372$ $p=0.018$	$r_s=-0.109$ $p=0.505$	$r_s=-0.310$ $p=0.052$
Duchenne smiles intensity	$r_s=0.486$ $p=0.001$	$r_s=0.090$ $p=0.580$	$r_s=-0.098$ $p=0.549$	$r_s=-0.393$ $p=0.012$	$r_s=-0.141$ $p=0.387$	$r_s=-0.279$ $p=0.081$
Non Duchenne smiles (duration)	$r_s=0.296$ $p=0.063$	$r_s=0.081$ $p=0.621$	$r_s=0.016$ $p=0.920$	$r_s=-0.396$ $p=0.011$	$r_s=-0.033$ $p=0.842$	$r_s=-0.448$ $p=0.004$
Non Duchenne smiles intensity	$r_s=0.463$ $p=0.003$	$r_s=-0.010$ $p=0.952$	$r_s=-0.119$ $p=0.464$	$r_s=-0.239$ $p=0.137$	$r_s=-0.052$ $p=0.750$	$r_s=-0.273$ $p=0.089$

BMI= Body mass index; EDE-Q= Eating disorder examination questionnaire; HADS-A= Hospital anxiety and depression scale, anxiety subscale; HADS-D= Hospital anxiety and depression scale, depression subscale; TAS-20= Toronto alexithymia scale; r_s = Spearman's rank correlation coefficient.

Bonferonni correction applied, statistical significance at **$p<0.008$**

FACIAL EXPRESSION OF POSITIVE EMOTIONS IN INDIVIDUALS WITH EATING
DISORDERS

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Abstract

A large body of research has associated Eating Disorders with difficulties in socio-emotional functioning and it has been argued that they may serve to maintain the illness. This study aimed to explore facial expressions of positive emotions in individuals with Anorexia Nervosa (AN) and Bulimia Nervosa (BN) compared to healthy controls (HC), through an examination of the Duchenne smile (DS), which has been associated with feelings of enjoyment, amusement and happiness (Ekman et al., 1990). Sixty participants (AN=20; BN=20; HC=20) were videotaped while watching a humorous film clip. The duration and intensity of DS were subsequently analysed using the Facial Action Coding System (FACS) (Ekman and Friesen, 2003). Participants with AN displayed DS for shorter durations than BN and HC participants, and their DS had lower intensity. In the clinical groups, lower duration and intensity of DS were associated with lower BMI, and use of psychotropic medication. The study is the first to explore DS in people with eating disorders, providing further evidence of difficulties in the socio-emotional domain in people with AN.

Keywords: Anorexia Nervosa, Bulimia Nervosa, Duchenne smile, Facial Expression, Emotion

1. Introduction

Facial expressions play a key role in human social interaction. They convey people's emotional experience (Ekman, 1992) and are used as social signals that communicate information to others (Fridlund, 1994). They are also essential for establishing rapport (Tickle-Degnen, 2006), deepening people's sense of connection and alliance during social interaction (Schmidt and Cohen, 2001). In contrast, lack of facial expression can be interpreted as an attempt to avoid attention in social settings, becoming undetected (Fridlund, 1994). Studies on individuals with limited facial expression indicate that people perceive them as reserved and unhappy (Tickle-Degnen and Doyle Lyons, 2004; Bogart et al., 2014) and report being less interested in establishing friendship ties with them (Hemmesch et al., 2009).

Facial expressions of positive emotions, such as smiling, have been related to cooperative intentions (Schmidt and Cohen, 2001), readiness to play or connect (Fridlund, 1994), and social rewards (Shore and Heerey, 2011). People associate smiling with happiness, positive intentions (Floyd and Burgoon, 1990), and increased sociability (Matsumoto and Kudoh, 1993).

Early on, Charles Darwin noted that spontaneous smiles were characterized by the activation of the muscle that contracts the outer corner of the eyebrows (i.e., orbicularis oculi) producing wrinkles in the corner of the eyes, in addition to the zygomaticus major, which moves the corner of the lips upwards towards the cheekbones (Darwin, 1872). This is known as the Duchenne smile (DS) (Duchenne, 1990; Ekman et al., 1990). DS have been associated with reports of enjoyment, amusement and happiness (Ekman et al., 1990; Ruch, 1995), as well as specific patterns of brain activity (Ekman, 1990, Davidson et al., 1990). In contrast, Non-Duchenne smiles (NDS) do not involve the action of the orbicularis oculi, and are not

associated with the experience of positive affect. Whereas DS have shown to evoke positive emotions in others, promoting positive social interactions and well being, NDS do not (Keltner and Bonanno, 1997; Harker and Keltner, 2001). Instead, NDS may be displayed in a deliberate attempt to convince others that a positive emotion is being felt when it is not (Ekman and Friesen, 1982), or as a way of signalling anticipation of the possibility of experiencing enjoyment (Ekman et al., 1990), and is often produced in response to social demands (Hess and Bourgeois, 2010).

Facial expression is part of a coordinated system of emotional responses (Levenson, 1994). It has been argued that in people who experience psychological difficulties, elements of this system may lack coordination, thus becoming dysfunctional (Rosenberg and Ekman, 1994). Studies in clinical populations have shown differences in the expression of DS in response to positive stimuli, compared to healthy controls (HC). For example, individuals suffering from depression have been found to produce fewer DS when exposed to positive stimuli (Ekman et al., 2005) and to show smiles that were followed by negative affect-related expressions in response to amusing film clips (Reed et al., 2007). Participants with schizophrenia display fewer DS when induced to feel positive emotions through remembering biographic emotional situations (Kohler et al., 2008). Similar results have been found for participants with post-traumatic stress disorder during a psychodynamic interview (Kirsch and Brunnhuber, 2007).

Eating disorders are characterized by disturbances in patients' eating patterns, body image or body weight, which may lead to physical, cognitive or social difficulties (Fairburn and Harrison, 2003; Tchanturia et al., 2013). People with eating disorders exhibit high levels of comorbidity with disorders that have shown to be related to reduced facial expression, such as anxiety and depression (Herzog et al., 2000). In addition, socio-emotional difficulties

found in eating disorders include high levels of alexithymia (Nowakowski, et al., 2013), social anhedonia (Tchanturia et al., 2012), self-silencing (i.e., the tendency to avoid expressing negative emotions) (Hambrook et al., 2011), and fear of the social consequences of expressing emotions (Ioannou and Fox, 2009; Hambrook et al., 2011). It has been proposed that socio-emotional difficulties may contribute to the maintenance of the eating disorder psychopathology (Treasure et al., 2012; Schmidt and Treasure, 2006; Speranza et al., 2007) and in the case of AN, that eating disorder symptoms function, in part, to help the individual cope with aversive emotional states (Wildes et al., 2010).

A few studies have investigated facial expressions in people with eating disorders (Davies et al., 2011; Davies et al., 2013; Rhind et al., 2014). Davies and colleagues (2011) found that adult AN patients showed fewer facial expressions when watching negative and positive films, and reported feeling less positive emotions and similar levels of negative emotions, compared to HC. Similar results were described in young people with AN (Rhind et al., 2014). Claes and colleagues (2012) used a different experimental procedure to monitor facial expression of anger and joy in AN and BN participants when playing a therapeutic video game and reported that AN patients exhibited less anger through their facial expressions compared to HC. In BN participants, facial expression of anger was not significantly reduced compared to HC. The study found no differences among the groups in their facial expressions of joy. In a second study using the same paradigm, patients with BN showed higher levels of joyous facial expressions, and reduced facial expression of anger compared to HC (Tarrega et al., 2014). Reduced expression of emotions may contribute to the difficulties in the socio emotional area, worsening the impact of the eating disorder in patients' social functioning (Tchanturia et al., 2013).

The studies described above provide preliminary evidence suggesting that patients with AN and BN show reduced negative facial emotional expression (sadness and anger) compared to HC. However, results for facial expressions of positive emotions are more equivocal: AN showed fewer positive facial expressions compared to HC when using film clips as mood elicitors, but not when using a video game. Furthermore, BN participants seem to display as many positive facial expressions as HC. Studies on positive emotions are scarce in the eating disorders field, and there is a need for further investigation in the area (Tchanturia, 2015). Therefore, this study aimed to build upon previous findings, by further investigating positive facial expression of emotions in AN and BN. Specifically, examining the expression of DS as an expression of genuine positive affect and potential benefits for well being, in comparison to NDS.

Based on previous findings, it was hypothesized that participants with AN will show fewer DS and NDS, compared to HC. Even though the literature on BN is more limited, it was hypothesized that this group will produce similar levels of DS and NDS to HC. To our knowledge, this is the first study to investigate DS in people with eating disorders.

2. Method

2.1. Participants

Sixty adult women, grouped into 20 AN (9 restricting type, and 11 binge-eating/purging type), 20 BN and 20 HC, were included in the study. Given that studies using FACS were not available in the eating disorders literature, studies carried out on other psychiatric populations (mainly schizophrenia and mood disorders) were used to estimate the sample size. It was estimated that a sample size of 20 participants per group would allow detecting medium to large effect sizes with 80% of power, setting $\alpha < 0.01$. Participants with

eating disorders were recruited from specialist eating disorders services, and through advertisement on the Beat website (<http://www.b-eat.co.uk/>). The HC group was recruited from the local community. Eating disorder diagnosis was assessed using the Eating Disorders module of the Structured Clinical Interview for DSM-IV-TR Axis I Disorders (SCID-I) (First et al., 2002). The inclusion criterion for the clinical groups was a diagnosis of AN or BN, according to DSM-5 (APA, 2013). A body mass index less than 18.5 was used as a threshold for AN diagnosis. Participants were excluded from the study if they have had a head injury, autism spectrum disorders, and psychosis, were not fluent in English, or were unable to provide informed consent. The same exclusion criteria as well as the absence of current or past eating disorder were applied for the HC group. Participants were compensated for their time with £10.

2.2. Measures

2.2.1. Body mass index (BMI in kg/m²): This was calculated from measures of height and weight obtained on the day of the assessments.

2.2.2. Structured Clinical Interview for DSM disorders (SCID-I) (First et al., 2002): The eating disorders module of the SCID-I was used to assess current or past diagnosis in all participants. In order to adjust the interview to DSM-5 criteria, amenorrhea was not required for AN diagnosis, and the frequency of binge eating and purging behaviour was reduced to once a week for the diagnosis of BN.

2.2.3. Eating Disorder Examination Questionnaire (EDE-Q) (Fairburn and Beglin, 1994): This 36 item self-report questionnaire is designed to assess eating disorders symptomatology. It has four subscales (i.e., dietary restraint, eating concern, weight concern, and shape concern) and a global score that ranges from 0 to 6.

2.2.4. Hospital Anxiety and Depression Scale (HADS) (Zigmond and Snaith, 1983): The HADS is a 14-item self-report questionnaire with two subscales assessing anxiety and depression levels. Each subscale ranges from 0 to 21. The questionnaire has shown to have good validity and reliability (Bjelland et al., 2002).

2.2.5. Toronto Alexithymia Scale (TAS-20) (Bagby et al., 1994): A 20 item questionnaire widely used to assess alexithymia, which is defined as difficulty in identifying and describing emotions. This questionnaire has good psychometric properties (Parker et al., 2003). The questionnaire consists of three subscales (i.e., difficulty identifying feelings, difficulty describing emotions, and externally oriented thinking) and a total score that ranges from 20 to 100.

2.2.6. Positive and Negative Affect Scale (PANAS) (Watson et al., 1988): The PANAS is a 20 items two-factors self-report scale developed to assess positive and negative affect. In the current study, the positive affect scale was used to assess the extent to which the film clip was able to induce positive affect in the participants. The positive affect PANAS scale has 10 descriptors (i.e., attentive, interested, alert, excited, enthusiastic, inspired, proud, determined, strong, and active) and its score ranges from 10 to 50.

Internal consistencies (α) for the measures in the current sample were: EDE-Q: 0.98; HADS Anxiety: 0.72; HADS Depression: 0.69; TAS-20: 0.92; and PANAS positive: 0.89.

2.3. Experimental Task

First, a neutral film depicting waves was presented for 30 seconds. Next, participants completed the positive PANAS questions (pre-film), in order to establish a baseline measure of positive affect before the emotion elicitation. Following this, a 2 minutes clip showing a

humorous wedding ceremony was shown. This clip was taken from the film “Four Weddings and a Funeral” and it was chosen because it has shown in previous studies to elicit positive emotions in people with AN and HC (e.g. Davies et al., 2011). Finally, the positive PANAS questions were repeated (post-film). Participants were alone during the task and were aware that they were being recorded. Videos and instructions were shown on a 13-inches laptop computer screen with a built-in camera that recorded the participant’s facial expressions during the task.

2.4. Procedure

Participants attended one session during which all procedures were carried out. As part of the informed consent participants were informed that the purpose of the study was “to explore the way people with and without eating disorders deal with emotions”, and were asked for their permission to be videotaped during the experimental procedures. After they gave their informed consent, the SCID was conducted, and weight and height were measured. Then, participants completed the experimental task and questionnaires. The videos showing participants' facial expressions while watching the humorous film were then coded using the Facial Action Coding System (FACS). The study was approved by the National Health Research Ethics Services Committee (13/LO/0201).

2.5. Coding of Facial Expression

The Facial Action Coding System (FACS) was developed by Ekman and Friesen for measuring observable facial expressions (Ekman and Friesen, 2003). It provides a method to objectively code any anatomically possible action produced in the face using 44 action units

(AUs), in which each AU describes the movement of specific muscles in the face. The coding system can be used to identify action units (AUs), their intensity, as well as combinations of AUs. In FACS, the DS is identified as a combination of AU12 (lip corners pulling, by the action of the zygomaticus major) and AU6 (cheek raising, by the action of the orbicularis oculi), and differentiated from NDS, which does not involve AU6. For a detailed description of FACS, see Ekman and Rosenberg (2005).

Videos were coded by two coders (SH; CH), who were blind to the participants' clinical status (AN, BN, or HC) and to the study hypotheses, under the supervision of MMD. All coders were certified in FACS. All 44 AUs were coded, and then AU6 and AU12 were selected for analysis. Duration and intensity were used as outcome measures. A measure of proportional viewing duration was calculated by dividing the time (in seconds) a participant had spent displaying the AU combination by the task duration in minutes. For example, if a participant displayed an AU combination for a total of 4 seconds during the 2-minute film clip then the measure would be 4 seconds divided by 2 minutes. The intensity of the AU combination was coded on a 5-point ordinal scale, from trace to maximum intensity.

The AU combinations for DS and NDS were coded exclusively, and did not overlap. In order to assess inter-coder reliability for AU6 and AU12, seven videos (12%) were coded by both coders (SH; CH). The overall agreement percentage was 92%. Mean Cohen's Kappa was 0.80, which indicates excellent agreement (Sayette et al., 2001).

2.6. Data Analysis

SPSS version 22 was used to analyse the data. Prior to conducting all analyses, distributions were examined to evaluate normality. Non-parametric analyses of variance were

conducted for data that was not normally distributed (Kruskal-Wallis and Mann–Whitney U post-hoc tests). Effect sizes were calculated by using Cohen’s *d* (Cohen, 2013) for parametric tests, and Rosenthal’s *r* (Rosenthal and Rubin, 2003) for non-parametric tests. In order to test the mood induction, repeated measures ANOVA was used comparing pre-film and post-film PANAS (within-group) among the three groups (AN, BN, or HC; between-subject factor). ANOVA and post-hoc t-tests were performed to compare the three groups on smile duration and intensity, when data was normally distributed. In order to explore associations of DS and NDS in the clinical group, AN and BN participants were grouped together (n=40) and Spearman correlations were calculated between the smiles and BMI, length of illness, EDE-Q, HADS-A, HADS-D, and TAS-20 measures. To explore the effect of medications in DS and NDS the clinical group was split into clinical participants who were taking medications (n=17) and those who were not (n=23). Mann Whitney U test and Rosenthal’s *r* effect size were calculated to compare the duration and intensity of DS and NDS in both groups. Bonferonni correction for multiple testing was applied.

3. Results

Participant’s demographic and clinical characteristics are described in Table 1. As expected, clinical participants differed from HC on measures of eating disorders, anxiety, depression, and alexithymia. In addition, AN participants had lower BMI than BN and HC groups. Eating disorder participants did not differ on EDE-Q subscales, although there was a trend towards significant difference in dietary restraint (EDE-Q diet. rest.: $M_{AN}= 4.29$, $M_{BN}=3.31$, $t(38)= 1.98$, $p=0.06$). There was no difference in the length of illness of AN and BN participants.

----- INSERT TABLE 1----

Sixty percent of the participants with AN were taking psychotropic medication at the time of the study (n=12). The majority was using a combination of selective serotonin reuptake inhibitors (SSRI) and Olanzapine (n=4), or SSRI exclusively (n=3); other AN participants were taking benzodiazepines (n=2) or other psychotropic medication (n=3). On the other hand, 25% of the participants with BN were using psychotropic medication (n=5), all taking SSRI. None of the HC participants was taking psychotropic medications.

3.1. Mood induction

Pre-film and post-film PANAS were compared to test the extent to which the film had been able to produce a change in participants' affect. Results indicated that there was a significant effect of film, with a significant increase in positive affect after viewing the film ($F(1,57)= 18.7, p < 0.01$). There was no significant effect of group ($F(2,57)=0.8, p=0.44$) and the group X film interaction was not significant ($F(2,57)= 0.5, p= 0.62$), suggesting similar increase in positive affect in all groups after viewing the film clip (Figure 1).

----- INSERT FIGURE 1-----

3.2. Duchenne smiles (DS)

Analyses of variance revealed that the groups differed significantly in duration and intensity of DS (Table 2). Post-hoc tests indicated that the AN group had significantly less DS duration and intensity compared to the BN group and to the HC group. BN participants did not differ from HC on intensity and duration. Effect sizes were between medium and large.

----INSERT TABLE 2----

3.3. Non-Duchenne smiles (NDS)

The analyses of variance indicated that the groups differed in duration and intensity of NDS. Post-hoc analyses showed less duration of NDS for both eating disorder groups compared to HC. AN and BN groups were not found to significantly differ in their duration of NDS. AN participants were shown to have significantly less intense NDS compared to the BN and HC groups, but the BN group did not differ from the HC group on NDS intensity. Effect sizes were small to large.

3.4. Association with clinical characteristics within the clinical sample

In order to explore the association of DS and NDS with clinical characteristics, AN and BN participants were grouped together (n=40) and their association with BMI, length of illness, eating disorder symptoms, anxiety, depression, and alexithymia was investigated. It was decided to investigate the clinical group as a whole because of the evidence of high diagnostic crossover between AN and BN (Eddy et al., 2008), and to ensure sufficient power for the analysis. Results indicated that in the clinical group, DS duration and intensity were significantly associated with BMI. None of the other clinical characteristics (length of illness, eating disorder symptoms, anxiety, depression, and alexithymia) were found to be significantly associated with DS. When exploring associations within the AN group (n=20), similar results were obtained with significant associations between DS intensity and BMI ($r_s=0.49$, $p=0.03$), and a trend towards significance in the case of DS duration and BMI ($r_s=0.44$, $p=0.05$).

In the eating disorders group, the duration of NDS was found to be negatively associated with TAS-20, and NDS intensity was significantly associated with BMI. NDS was not found to be associated with the other clinical measures (see Table 3). On the other hand, in the AN participants, NDS was associated with anxiety ($r_s=-0.50$, $p=0.02$).

----- INSERT TABLE 3-----

In regards to medication use, clinical participants who were taking psychotropic medications at the time of the study had less DS duration ($U(38)=117.00$; $p=0.03$; $r=-0.36$), and their DS were less intense ($U(38)=112.00$; $p=0.02$; $r=-0.39$). There were no differences on duration or intensity of NDS between medicated and non medicated clinical participants (duration: $U(38)=135.50$; $p=0.10$; intensity: $U(38)=163.00$; $p=0.39$).

4. Discussion

Smiles are potent social signals that are vital for human communication (La France, 2011), and thus their examination in people with eating disorders can offer significant insight into their socio-emotional functioning and contribute to treatment innovations. The present study aimed to investigate positive facial expression in people with eating disorders through an examination of Duchenne smile (DS) expressed in response to a positive, humorous film clip. It was hypothesised that participants with AN will exhibit reduced DS and NDS when compared to HC, and that BN participants will produce DS and NDS at similar levels to HC.

Results indicated that the film clip successfully increased positive emotions in all participants, but they differed in their facial expression. Specifically, participants with AN displayed DS for shorter durations than BN and HC participants, and their DS had lower intensity. These results extend previous findings of reduced positive facial expression in AN,

by obtaining similar results using a different, more detail-oriented facial expression coding system (Davies et al., 2011; Rhind et al., 2014).

Duchenne smiles (DS) express genuine or authentic enjoyment. Because emotion expression plays a central role in establishing relationships (Keltner and Kring, 1998), the reduced expression of DS in the AN group might reflect broad social-signalling difficulties. Indeed, inhibited emotional expression has been shown to make it more likely for others to perceive the inhibited person as untrustworthy or inauthentic (e.g., English and John, 2013) and to reduce social connectedness (e.g., Mauss et al., 2011). It has also been hypothesized that people who show reduced positive facial expression are trying to avoid people's attention (Fridlund, 1994). AN is a disorder highly comorbid with social phobia (Swinbourne et al., 2012) and there is evidence that people with AN maintain less eye contact than HC (Cipolli et al., 1989) and experience high levels of social anhedonia (Tchanturia et al., 2012; Harrison et al., 2014). In this context, it is likely that the reduced expression of positive affect would contribute to maintain this pattern of social avoidance in AN.

DS has also been associated with social reward (Shore and Heerey, 2011), therefore, the reduced expression of DS in the AN group may reflect diminished temperamental reward sensitivity that characterizes disorders of overcontrol such as AN, autism spectrum disorders, and obsessive compulsive personality disorder (Lynch et al., 2013; Lynch, in press). Heightened temperamental threat sensitivity and diminished reward sensitivity are hypothesized to bias a person to notice the potential for harm over the potential for reward when interacting with others or encountering ambiguous stimuli making it less likely for them to respond with genuine enjoyment or pleasure (Lynch et al., in press; Clark, 2005). Smiling faces have been shown to activate reward-anticipation areas in the brain (Aharon et

al., 2001) and AN has been shown to exhibit lower dopamine mediated anticipatory reward relative to BN (Kaye et al., 2013 for review).

Results of this study showed differences in the duration and intensity of DS between AN and BN participants, this may be explained at least in part, by the fact that BN is a disorder characterized by impulsivity (Harrison et al., 2010) while AN is characterized by overcontrol (Lynch et al., 2013). Our results are similar to findings from Claes and colleagues (2012) who did not find reduced facial expression of joy in BN participants.

Furthermore, participants within the clinical sample with lower BMI, were found to present DS at a lower duration and intensity, compared to those with higher BMI. Given that other eating disorder psychopathology measures, such as length of illness and EDE-Q, were not associated with DS, this finding suggests that starvation may explain, at least in part, the differences in the results found for people with AN and BN. Future studies including participants who are weight restored, but have AN related psychopathology may be able to enlighten the role of starvation in the expression of positive emotions in AN.

An alternative explanation for the differences between the clinical groups in the production of DS and NDS may relate to different levels of social anxiety in AN and BN. It is known that AN is highly comorbid with social phobia (Swinbourne et al., 2012), and there is preliminary evidence that shyness may influence social skills in AN (Wincoff et al., 2015). Since participants were aware they were being filmed during this study, those with AN may have experienced social anxiety and therefore may have been more cautious of their emotional expression. The negative associations between anxiety and both DS and NDS production may provide support for this explanation, even though they were not significant after correcting for multiple testing. Thus, the influence of social anxiety in positive emotion

expression when evaluated using videotaped tasks, such as the one used in the current study, may need further investigation.

In order to explore the effects of psychotropic medications in positive emotion expression (i.e. DS) the clinical group was split according to medication use. Participants taking medications (mostly on SSRI, either exclusively or in combination with olanzapine) showed significantly less DS duration and intensity. These findings may seem to contradict evidence of enhanced expression of positive emotions after SSRI treatment found in people with depression (Girard et al., 2014). However, it is worth noting that the majority of participants taking medications in this study were underweight (i.e. AN), and it is known that antidepressants are less effective in this population (Claudino, et al., 2009). One explanation for our findings may be that participants taking antidepressants were the ones with more severe depressive symptoms, and depression has been linked to reduced expression of positive affect (Ekman et al., 2005; Girard, 2014). However, in our study depressive symptoms did not correlate to duration or intensity of DS. Therefore, the relation between medication and expression of positive emotions remains unclear. To our knowledge, this is the first study to explore the effects of medication in emotion expression. The results highlight the need to further investigate the impact of psychotropic medication on emotion expression.

In contrast to the results for DS, differences between AN and BN participants on NDS were not statistically significant. Nevertheless, this result should be taken with caution, because the difference approached significance and the effect size was small, but not negligible. Thus, it is unclear whether the lack of difference between AN and BN participants reflects true similarities in NDS expression, or is a result of lack of power. Future studies

with a larger sample size might clarify the differences between AN and BN participants in NDS expression.

In this study, both AN and BN groups presented significantly less NDS duration than the HC group. NDS intensity was found to be significantly less for AN participants compared to BN and HC groups. NDS is usually shown in response to social demands (Hess and Bourgeois, 2010), and according to Papa and Bonanno (2008) NDS displayed in positive situations may be appropriate as a signal of social politeness, increasing social integration. Thus, results may indicate that people with eating disorders are less able to comply with social conventions related to the expression of positive emotions in positive contexts. Alternatively, people with eating disorders may be less expressive in general, for both emotional and non-emotional expressions.

In our study, clinical participants with higher levels of alexithymia showed lower NDS duration. Since NDS tend to be expressed as social conventions, rather than expressions of real enjoyment, this finding may suggest that in people with eating disorders, the difficulties identifying and verbalising internal emotional experiences relate to a lack of awareness of social conventions ruling the display of positive affect. It may be beneficial for future studies to explore this idea further.

The study findings have relevant clinical implications. People with AN have reported experiencing difficulties making friends before the eating disorder onset (Doris et al., 2014), and people with eating disorders report that their illness affects social relationships more than any other aspect of life (Tchanturia et al., 2013). Building new social relationships during recovery may be harder for individuals with eating disorders because people are less motivated in building friendships with individuals who do not express emotions (Hemmesch

et al., 2009). Moreover, reduced positive facial expression can have an impact on rapport (Tickle-Degnen, 2006), interfering with the therapeutic relationship during treatment.

This study provides further evidence for the need to include interventions aimed at improving socio-emotional processing of positive emotions in eating disorders treatment (Tchanturia et al., 2015), particularly in those with AN and using psychotropic medication. Research of this nature could inform already existing therapies addressing emotion functioning in eating disorders, such as Cognitive Remediation and Emotional Skills Training (CREST) (Tchanturia et al., 2014), Emotion Acceptance Behaviour Therapy (EABT) for Anorexia Nervosa (Wildes and Marcus, 2011), and Radically Open-Dialectical Behaviour Therapy (RO-DBT) (Lynch et al., in press).

There are limitations to the present study. For example, even though the researchers coding the videos were blind to the group allocation of the participants, some AN participants were visibly underweight and therefore their group allocation may have been revealed. In addition, all participants were female. Given the evidence that women tend to smile more than men (Hess and Bourgeois, 2010), it would be relevant to explore this area in men with eating disorders. Finally, the association analysis within the AN participants carried out in this study needs to be seen as exploratory, given the small sample size for the AN group. In future studies it would be desirable to include a higher number of participants to examine differences in AN and BN in facial expression of positive emotions.

Future research could replicate this study including a group of weight restored AN participants, to better understand the role of starvation in the results. In addition, studies should explore differences in the expression of negative emotions to better understand if the reduced expression exhibited by AN participants is specific to positive emotions, or

generalized to all emotions. Finally, future studies may aim to replicate these findings in social interaction paradigms.

To our knowledge, the study is the first to investigate DS as an expression of genuine positive affect in people with AN and BN. The findings provide empirical support of difficulties in facial expression of positive emotions in people with AN and underline the need to further explore the role of BMI and psychotropic medications in the expression of positive emotions in people with eating disorders.

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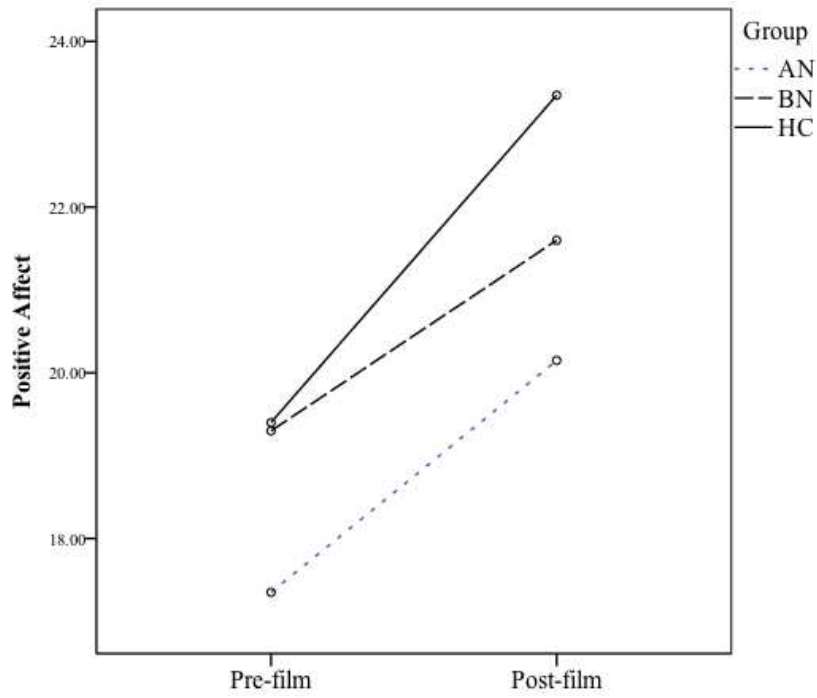
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Figure 1: Pre-film and post-film positive affect PANAS scores.



AN=Anorexia nervosa; BN= bulimia nervosa; HC= healthy controls.

Table 1. Demographic and clinical characteristics

	AN	BN	HC	Group	Post-hoc tests		
	(n=20)	(n=20)	(n=20)	Statistics	AN vs. BN	AN vs. HC	BN vs. HC
	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>				
Age	28.85 (9.75)	26.85 (6.75)	26.40 (7.60)	$F(2,57)=0.52$ $p=0.60$	N/A	N/A	N/A
BMI	15.59 (1.83)	22.15 (3.02)	22.47 (2.68)	$F(2,57)=45.97$ $p<0.01$	$t(38)=8.29$ $p<0.01$ $d=2.63$	$t(38)=9.49$ $p<0.01$ $d=3.00$	$t(38)=0.36$ $p=0.72$ $d=0.11$
Length of Illness	11.55 (11.26)	7.95 (6.46)	N/A	$t(38)=1.24$ $p=0.23$	N/A	N/A	N/A
EDE-Q	4.38 (1.04)	3.98 (1.37)	0.48 (0.42)	$F(2,57)=88.29$ $p<0.01$	$t(38)=1.02$ $p=0.31$ $d=0.32$	$t(25)=15.51$ $p<0.01$ $d=4.92$	$t(23)=10.97$ $p<0.01$ $d=2.82$
HADS-A	13.15 (3.60)	12.05 (2.82)	5.95 (1.85)	$F(2,57)=37.08$ $p<0.01$	$t(38)=1.08$ $p=0.29$ $d=0.34$	$t(28)=7.95$ $p<0.01$ $d=2.52$	$t(38)=8.09$ $p<0.01$ $d=2.56$
HADS-D	10.60 (3.15)	9.70 (3.39)	3.85 (1.60)	$F(2,57)=33.61$ $p<0.01$	$t(38)=0.87$ $p=0.39$ $d=0.28$	$t(28)=8.54$ $p<0.01$ $d=2.70$	$t(27)=6.98$ $p<0.01$ $d=2.21$
TAS-20	60.45 (4.79)	56.35 (14.25)	34.75 (2.52)	$F(2,57)=12.36$ $p<0.01$	$t(38)=0.95$ $p=0.35$ $d=0.39$	$t(26)=8.02$ $p<0.01$ $d=6.72$	$t(25)=6.27$ $p<0.01$ $d=2.11$

AN= anorexia nervosa; BN= bulimia nervosa; HC= healthy control; n= number of participants; *M*= mean; *SD*= standard deviation; *F*= Anova test; N/A= non applicable; BMI= body mass index; *t*= t-test; *d*= Cohen's *d* effect size test; EDE-Q= Eating disorders examination questionnaire; HADS-A= Hospital anxiety and depression scale, anxiety subscale; HADS-D= Hospital anxiety and depression scale, depression subscale; TAS-20 =

Toronto alexithymia scale.
Bonferonni correction applied, statistical significance at $p < 0.016$

Table 2: Duchenne and Non-Duchenne smiles in clinical and HC groups

	AN (n=20)	BN (n=20)	HC (n=20)	Group Statistics	Post-hoc tests		
	<i>Mdn (IQR)</i>	<i>Mdn (IQR)</i>	<i>Mdn (IQR)</i>		AN vs. BN	AN vs. HC	BN vs. HC
Duchenne smiles duration (sec/min)	0.00 (0.42)	0.83 (1.59)	2.08 (2.28)	$\chi^2(2)=15.86$ $p<0.01$	$U=114.00$ $p<0.01$ $r=0.39$	$U=71.50$ $p<0.01$ $r=0.57$	$U=115.00$ $p=0.02$ $r=0.37$
Duchenne smiles intensity	0.00 (1.75)	3.00 (2.50)	3.00 (1.50)	$\chi^2(2)=18.25$ $p<0.01$	$U=88.00$ $p<0.01$ $r=0.51$	$U=62.00$ $p<0.01$ $r=0.63$	$U=159.50$ $p=0.23$ $r=0.19$
Non Duchenne smiles duration (sec/min)	0.83 (1.66)	1.66 (2.50)	3.74 (2.49)	$\chi^2(2)=16.26$ $p<0.01$	$U=135.50$ $p=0.08$ $r=0.28$	$U=62.00$ $p<0.01$ $r=0.60$	$U=100.50$ $p<0.01$ $d=0.43$
Non Duchenne smiles intensity	2.00 (1.00)	3.00 (1.00)	3.00 (1.00)	$\chi^2(2)=20.26$ $p<0.01$	$U=107.50$ $p<0.01$ $r=0.41$	$U=49.00$ $p<0.01$ $r=0.67$	$U=115.50$ $p=0.02$ $r=0.34$

AN= anorexia nervosa; BN= bulimia nervosa; HC= healthy control; n= number of participants; *Mdn*= median; *IQR*= interquartile range; **Sec/min= seconds per minute**; *U*= Mann Whitney *U* test; χ^2 = Kruskal-Wallis test; *r*= Rosenthal's *r* effect size test; *t*= t-test; *d*= Cohen's *d* effect size test.
Bonferonni correction applied, statistical significance at **$p<0.016$**

Table 3: Correlations between DS, NDS and clinical characteristics within the clinical sample

	BMI	Length of Illness	EDE-Q	HADS-A	HADS-D	TAS-20
Duchenne smiles (duration)	$r_s=0.426$ $p=0.006$	$r_s=0.097$ $p=0.551$	$r_s=-0.053$ $p=0.746$	$r_s=-0.372$ $p=0.018$	$r_s=-0.109$ $p=0.505$	$r_s=-0.310$ $p=0.052$
Duchenne smiles intensity	$r_s=0.486$ $p=0.001$	$r_s=0.090$ $p=0.580$	$r_s=-0.098$ $p=0.549$	$r_s=-0.393$ $p=0.012$	$r_s=-0.141$ $p=0.387$	$r_s=-0.279$ $p=0.081$
Non Duchenne smiles (duration)	$r_s=0.296$ $p=0.063$	$r_s=0.081$ $p=0.621$	$r_s=0.016$ $p=0.920$	$r_s=-0.396$ $p=0.011$	$r_s=-0.033$ $p=0.842$	$r_s=-0.448$ $p=0.004$
Non Duchenne smiles intensity	$r_s=0.463$ $p=0.003$	$r_s=-0.010$ $p=0.952$	$r_s=-0.119$ $p=0.464$	$r_s=-0.239$ $p=0.137$	$r_s=-0.052$ $p=0.750$	$r_s=-0.273$ $p=0.089$

BMI= Body mass index; EDE-Q= Eating disorder examination questionnaire; HADS-A= Hospital anxiety and depression scale, anxiety subscale; HADS-D= Hospital anxiety and depression scale, depression subscale; TAS-20= Toronto alexithymia scale; r_s = Spearman's rank correlation coefficient.

Bonferonni correction applied, statistical significance at **$p<0.008$**

Table 1. Demographic and clinical characteristics

	AN	BN	HC	Group	Post-hoc tests		
	(n=20)	(n=20)	(n=20)	Statistics	AN vs. BN	AN vs. HC	BN vs. HC
	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>				
Age	28.85 (9.75)	26.85 (6.75)	26.40 (7.60)	$F(2,57)=0.52$ $p=0.60$	N/A	N/A	N/A
BMI	15.59 (1.83)	22.15 (3.02)	22.47 (2.68)	$F(2,57)=45.97$ $p<0.01$	$t(38)=8.29$ $p<0.01$ $d=2.63$	$t(38)=9.49$ $p<0.01$ $d=3.00$	$t(38)=0.36$ $p=0.72$
Length of Illness	11.55 (11.26)	7.95 (6.46)	N/A	$t(38)=1.24$ $p=0.23$	N/A	N/A	N/A
EDE-Q	4.38 (1.04)	3.34 (1.37)	0.48 (0.42)	$F(2,57)=88.29$ $p<0.01$	$t(38)=1.02$ $p=0.31$	$t(25)=15.51$ $p<0.01$ $d=4.92$	$t(23)=10.97$ $p<0.01$ $d=2.82$
HADS-A	13.15 (3.60)	12.05 (2.82)	5.95 (1.85)	$F(2,57)=37.08$ $p<0.01$	$t(38)=1.08$ $p=0.29$	$t(28)=7.95$ $p<0.01$ $d=2.52$	$t(38)=8.09$ $p<0.01$ $d=2.56$
HADS-D	10.60 (3.15)	9.70 (3.39)	3.85 (1.60)	$F(2,57)=33.61$ $p<0.01$	$t(38)=0.87$ $p=0.39$	$t(28)=8.54$ $p<0.01$ $d=2.70$	$t(27)=6.98$ $p<0.01$ $d=2.21$
TAS-20	60.45 (4.79)	56.35 (14.25)	34.75 (2.52)	$F(2,57)=12.36$ $p<0.01$	$t(38)=0.95$ $p=0.35$	$t(26)=8.02$ $p<0.01$ $d=6.72$	$t(25)=6.27$ $p<0.01$ $d=2.11$

AN= anorexia nervosa; BN= bulimia nervosa; HC= healthy control; n= number of participants; *M*= mean; *SD*= standard deviation; *F*= Anova test; N/A= non applicable; BMI= body mass index; *t*= t-test; *d*= Cohen's *d* effect size test; EDE-Q= Eating disorders examination questionnaire; HADS-A= Hospital anxiety and depression scale, anxiety subscale; HADS-D= Hospital anxiety and depression scale, depression subscale; TAS-20 = Toronto alexithymia scale.

Bonferonni correction applied, statistical significance at $p < 0.016$

Table 2: Duchenne and Non-Duchenne smiles in clinical and HC groups

	AN (n=20)	BN (n=20)	HC (n=20)	Group Statistics	Post-hoc tests		
	<i>Mdn</i> (<i>IQR</i>)	<i>Mdn</i> (<i>IQR</i>)	<i>Mdn</i> (<i>IQR</i>)		AN vs. BN	AN vs. HC	BN vs. HC
Duchenne smiles duration (sec/min)	0.00 (0.42)	0.83 (1.59)	2.08 (2.28)	$\chi^2(2)=15.86$ $p<0.01$	$U=114.00$ $p<0.01$ $r=0.39$	$U=71.50$ $p<0.01$ $r=0.57$	$U=115.00$ $p=0.02$ $r=0.37$
Duchenne smiles intensity	0.00 (1.75)	3.00 (2.50)	3.00 (1.50)	$\chi^2(2)=18.25$ $p<0.01$	$U=88.00$ $p<0.01$ $r=0.51$	$U=62.00$ $p<0.01$ $r=0.63$	$U=159.50$ $p=0.23$
Non-Duchenne smiles duration (sec/min)	0.83 (1.66)	1.66 (2.50)	3.74 (2.49)	$\chi^2(2)=16.26$ $p<0.01$	$U=135.50$ $p=0.08$	$U=62.00$ $p<0.01$ $r=0.60$	$U=100.50$ $p<0.01$ $d=0.43$
Non-Duchenne smiles intensity	2.00 (1.00)	3.00 (1.00)	3.00 (1.00)	$\chi^2(2)=20.26$ $p<0.01$	$U=107.50$ $p<0.01$ $r=0.41$	$U=49.00$ $p<0.01$ $r=0.67$	$U=115.50$ $p=0.02$ $r=0.34$

AN= anorexia nervosa; BN= bulimia nervosa; HC= healthy control; n= number of participants; *Mdn*= median; *IQR*= interquartile range; **Sec/min= seconds per minute**; *U*= Mann Whitney *U* test; χ^2 = Kruskal-Wallis test; *r*= Rosenthal's *r* effect size test; *t*= t-test; *d*= Cohen's *d* effect size test.

Bonferonni correction applied, statistical significance at **$p<0.016$**

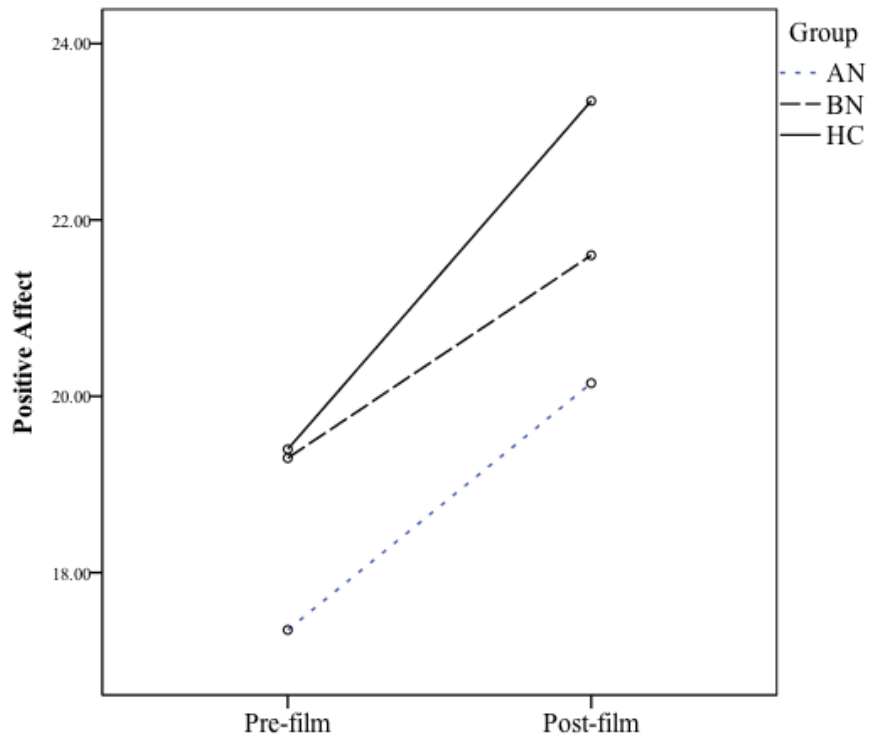
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	BMI	Length of Illness	EDE-Q	HADS-A	HADS-D	TAS-20
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Duchenne smiles intensity	$r_s=0.486$ $p=0.001$	$r_s=0.090$ $p=0.580$	$r_s=-0.098$ $p=0.549$	$r_s=-0.393$ $p=0.012$	$r_s=-0.141$ $p=0.387$	$r_s=-0.279$ $p=0.081$
Non Duchenne smiles (duration)	$r_s=0.296$ $p=0.063$	$r_s=0.081$ $p=0.621$	$r_s=0.016$ $p=0.920$	$r_s=-0.396$ $p=0.011$	$r_s=-0.033$ $p=0.842$	$r_s=-0.448$ $p=0.004$
Non Duchenne smiles intensity	$r_s=0.463$ $p=0.003$	$r_s=-0.010$ $p=0.952$	$r_s=-0.119$ $p=0.464$	$r_s=-0.239$ $p=0.137$	$r_s=-0.052$ $p=0.750$	$r_s=-0.273$ $p=0.089$

BMI= Body mass index; EDE-Q= Eating disorder examination questionnaire; HADS-A= Hospital anxiety and depression scale, anxiety subscale; HADS-D= Hospital anxiety and depression scale, depression subscale; TAS-20= Toronto alexithymia scale; r_s = Spearman's rank correlation coefficient.

Bonferonni correction applied, statistical significance at **$p<0.008$**

Figure 1: Pre-film and post-film positive affect PANAS scores.



AN=Anorexia nervosa; BN= bulimia nervosa; HC= healthy controls.